

38.7: BONE - BONE DEVELOPMENT

LEARNING OBJECTIVES

- Distinguish between intramembranous and endochondral ossification

Ossification, or osteogenesis, is the process of bone formation by osteoblasts. Ossification is distinct from the process of calcification; whereas calcification takes place during the ossification of bones, it can also occur in other tissues. Ossification begins approximately six weeks after fertilization in an embryo. Before this time, the embryonic skeleton consists entirely of fibrous membranes and hyaline cartilage. The development of bone from fibrous membranes is called intramembranous ossification; development from hyaline cartilage is called endochondral ossification. Bone growth continues until approximately age 25. Bones can grow in thickness throughout life, but after age 25, ossification functions primarily in bone remodeling and repair.

INTRAMEMBRANOUS OSSIFICATION

Intramembranous ossification is the process of bone development from fibrous membranes. It is involved in the formation of the flat bones of the skull, the mandible, and the clavicles. Ossification begins as mesenchymal cells form a template of the future bone. They then differentiate into osteoblasts at the ossification center. Osteoblasts secrete the extracellular matrix and deposit calcium, which hardens the matrix. The non-mineralized portion of the bone or osteoid continues to form around blood vessels, forming spongy bone. Connective tissue in the matrix differentiates into red bone marrow in the fetus. The spongy bone is remodeled into a thin layer of compact bone on the surface of the spongy bone.

ENDOCHONDRAL OSSIFICATION

Endochondral ossification is the process of bone development from hyaline cartilage. All of the bones of the body, except for the flat bones of the skull, mandible, and clavicles, are formed through endochondral ossification.

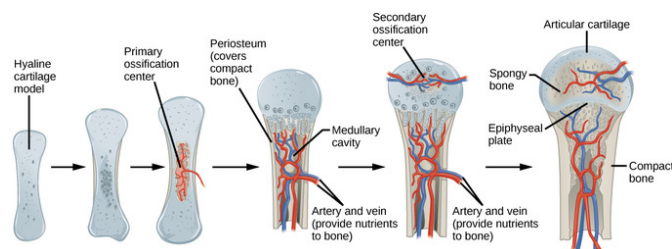


Figure 38.7.1: Process of endochondral ossification: Endochondral ossification is the process of bone development from hyaline cartilage. The periosteum is the connective tissue on the outside of bone that acts as the interface between bone, blood vessels, tendons, and ligaments.

In long bones, chondrocytes form a template of the hyaline cartilage diaphysis. Responding to complex developmental signals, the matrix begins to calcify. This calcification prevents diffusion of nutrients into the matrix, resulting in chondrocytes dying and the opening up of cavities in the diaphysis cartilage. Blood vessels invade the cavities, while osteoblasts and osteoclasts modify the calcified cartilage matrix into spongy bone. Osteoclasts then break down some of the spongy bone to create a marrow, or medullary cavity, in the center of the diaphysis. Dense, irregular connective tissue forms a sheath (periosteum) around the bones. The periosteum assists in attaching the bone to surrounding tissues, tendons, and ligaments. The bone continues to grow and elongate as the cartilage cells at the epiphyses divide.

In the last stage of prenatal bone development, the centers of the epiphyses begin to calcify. Secondary ossification centers form in the epiphyses as blood vessels and osteoblasts enter these areas and convert hyaline cartilage into spongy bone. Until adolescence, hyaline cartilage persists at the epiphyseal plate (growth plate), which is the region between the diaphysis and epiphysis that is responsible for the lengthwise growth of long bones.

KEY POINTS

- The ossification of the flat bones of the skull, the mandible, and the clavicles begins with mesenchymal cells, which then differentiate into calcium-secreting and bone matrix-secreting osteoblasts.
- Osteoids form spongy bone around blood vessels, which is later remodeled into a thin layer of compact bone.
- During endochondral ossification, the cartilage template in long bones is calcified; dying chondrocytes provide space for the development of spongy bone and the bone marrow cavity in the interior of the long bones.
- The periosteum, an irregular connective tissue around bones, aids in the attachment of tissues, tendons, and ligaments to the bone.
- Until adolescence, lengthwise long bone growth occurs in secondary ossification centers at the epiphyseal plates (growth plates) near the ends of the bones.

KEY TERMS

- osteoid:** an organic matrix of protein and polysaccharides, secreted by osteoblasts, that becomes bone after mineralization
- endochondral:** within cartilage
- chondrocyte:** a cell that makes up the tissue of cartilage
- diaphysis:** the central shaft of any long bone

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